APPENDIX F

DESCRIPTIONS OF ORNL RESEARCH PROJECTS IN THE WALKER BRANCH WATERSHED

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F. DESCRIPTIONS OF ORNL RESEARCH PROJECTS IN THE WALKER BRANCH WATERSHED

This appendix includes a response from the Oak Ridge National Laboratory (ORNL) regarding research land use on the Walker Branch Watershed. It includes brief descriptions of current and future research projects in the watershed area.

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March 13, 1998

Mr. Tracy C. Brown
Enterprise Advisory Services, Inc.
663 Emory Valley Road
Oak Ridge, Tennessee 37830-7751

Dear Mr. Brown:

Attached is our response to your questions regarding research land use on Walker Branch Watershed. You will note that our response in integrally linked, in the case of many projects, with determinations that will result from your information gathering with Ray Hosker and his people at NOAA/ATDD, and the modeling that I understanding your folks are doing in conjunction with them. We would appreciate the opportunity to be kept informed of modeling results as they are available, so that we might reevaluate current issues on the basis of that information.

This information reflects input and review from Drs. Amthor, Garten, Hanson, Huston, and Mulholland, all principal investigators on Walker Branch projects, and from Drs. Hildebrand, Jacobs, Loar, and myself on the Environmental Sciences Division management team.

Thank you for this opportunity to provide input to the NEPA process.

Sincerely,

David S. Shriner, Ph.D.
Head, Ecological Sciences Section
ENVIRONMENTAL SCIENCES DIVISION

DSS:lkm

Attachment

cc: J. S. Amthor
J. E. Cleaves
C. T. Garten
P. J. Hanson
S. G. Hildebrand
R. P. Hosker
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Brief Description of Current Research Projects in the Walker Branch Watershed

General Comments

Walker Branch Watershed (WBW) is one of the Nation's leading long-term environmental monitoring and research sites, with greater than 30 years of record of hydrology, primary productivity, and soil chemistry measurements that serve as the baseline for quantifying forest ecosystem response to changes in climate and atmospheric deposition associated with energy technologies. The WBW is a core component of the Oak Ridge National Environmental Research Park, an ORNL user facility, which hosts researchers from numerous other federal agencies and universities who conduct research on the watershed's projects in conjunction with ORNL scientists. One of the key collaborations, is the long-term partnership with forest micrometeorologists of the NOAA Atmospheric Turbulence and Diffusion Division in Oak Ridge, and additional input should be solicited from the NOAA staff. As a general statement, evaluation of the long-term effects of SNS operation is limited by uncertainties associated with the availability of quantitative information related to SNS thermal, water vapor, and trace gas emissions, and issues such as the means by which algae associated with the cooling towers will be controlled, and possible chemical loading associated with algaecidal measures. Also unknown are issues such as the effects of large paved surfaces as a potential heat sink, or source of volatile organic compounds.

In summary, Walker Branch Watershed is a research facility whose value transcends the lifetime of individual projects, and whose value increases exponentially with time, due to the limited number of long-term sites with comparable data records. Those effects of greatest concern are those which might potentially alter the long-term record at the site in such a way as to make it less valuable. To some extent, at least, opportunity for follow-on research based on current project results could be affected, if pre- and post-SNS startup data on WBW were unable to be compared. The most important of the potential impacts of SNS siting that we can identify with the information currently available are those related to the long-term atmospheric and deposition measurements at the NOAA Tower and National Atmospheric Deposition Program sites on the WBW. A critical assumption for the watershed-scale research on biogeochemical cycling and ecosystem process-related research on the watershed is that the NADP monitoring site is representative of the entire watershed area. Because of the location of these monitoring stations with respect to the proposed SNS, it is possible that the spatial representativeness of these sites would be altered, requiring additional monitoring on the watershed to quantify the level of impact and to recalibrate watershed-level inputs. Additionally, there is uncertainty associated with potential impacts to the groundwater hydrology of the Walker Branch Catchment through the possibility of construction impacts on subsurface communication of hydrologic systems under the ridge, which could impact the long-term streamflow record if it were to occur.

1

Current Research

1. **Throughfall Displacement Experiment (TDE)**. This major experiment for the DOE Program for Ecosystem Research involves forest stand-level experiments that are being used to understand the mechanisms of forest ecosystem response to changes in regional rainfall that may result from a warming global climate. This work focuses on belowground tree response, and mechanisms of whole plant water use, carbon utilization and drought tolerance of the deciduous forest tree species which make up the forest at the experimental site. Objectives of this project are to test for the occurrence of these mechanisms at the stand level, to determine which tree species/genera exhibit the greatest adaptive potential by the use of these mechanisms, and to determine whether the survival of various tree species is enhanced by these adaptive mechanisms.

   - affected by SNS construction? No.
   - affected by SNS operation? Not expected to be. Important uncertainty is spatial extent and magnitude of water vapor and temperature impacts of cooling towers.
   - affected by SNS closure? No.

2. **Long-Term Ecological Measurements of Ecosystem Response**. Measurements of hydrologic inputs and outputs, forest biomass and species composition, and soil chemistry have been made on WBW over the past 30 years. These long-term measurements are being made to quantify the response of the forest ecosystem to changes in climate and atmospheric deposition that are expected to occur. Specific measurements being made include precipitation volume and chemistry, dry deposition quantity and chemistry, vegetation biomass and species composition, soil chemistry, streamflow, and stream water chemistry. These measurements support DOE's (1) local, regional, and global research, and (2) environmental restoration activities (baseline measurements). The measurements are also used to test and extrapolate results from the Walker Branch climate change experiment (TDE) to the ecosystem and watershed scales. These measurements will provide the catchment-scale input/output budgets for new process-level research on nitrogen cycling and retention in the forest and stream ecosystems of Walker Branch. Wet and dry deposition measurements are part of the long-term, 200 site National Atmospheric Deposition Program, National Trends Network (NADP/NTN), and the associated Mercury Deposition Network (MDN) and Atmospheric Integrated Research Monitoring Network (AIRMON) sites. The mercury deposition monitoring site is one of 18 such sites nationwide, while the AIRMON site is one of nine. The Walker Branch NADP/NTN site is approaching 20 years of continuous operation as a precipitation chemistry monitoring station.
   - affected by SNS construction?
     - — potentially, by dust deposition - NADP/NTN, MDN, AIRMON
     - — hydrology- potentially, if construction impacts subsurface systems.
     - — productivity - No

- affected by SNS operation?
  - NADP/NTN, MDN, AIRMON - potentially, if results in change in amount of wet deposition at site because of water from cooling tower.
  - hydrology, productivity - Not expected to be impacted unless fog events are very frequent.
  - will chemicals/algaecides be used to maintain cooling towers?
- affected by SNS closure? No.

3. **Terrestrial Feedbacks to Regional Hydrologic Budgets**. Walker Branch Watershed is one of five primary sites for this work. This project seeks to enhance understanding of the contributions of closed-canopy, deciduous forest stands to local/regional hydrologic budgets. We are establishing a distributed set of instrumented forest plots across the Ohio-Tennessee watershed for continuous, multi-year monitoring of climate variables, soil water conditions, and tree and forest stand evapotranspiration. Measurements at these sites will be used to derive mechanistic relationships between total canopy conductance and environmental variables, and to test models of atmosphere-soil-plant hydrologic flux. The research will provide critical, multi-year data on temporal and spatial dynamics of terrestrial evapotranspiration and multi-depth soil water dynamics for upland hardwood forest ecosystems. These data will resolve the range of day-to-day and site-to-site variability in evapotranspiration to be expected throughout much of the eastern United States. The data from this project will also be shared with research groups of the GEWEX Continental-scale International Project (GCIP) to enhance the data bases against which they can test macro- and mesoscale climate models.

- affected by SNS construction? No.
- affected by SNS operation? No.
  - project completed before operation begins; follow-up measurements may or may not be comparable
- affected by SNS closure? No.

4. **Nitrogen Uptake, Retention, and Cycling in Stream Ecosystems: An Intersite ^{15}N Tracer Experiment**. The work being conducted in Walker Branch involves: (1) short-term (several hours) injections of a conservative tracer and application of a transient storage model to define hydrodynamic characteristics, (2) short-term injections of nutrients (NH_4, NO_3, PO_4) to determine relative uptake lengths of different nutrients and potential N deficiency, (3) whole-stream measures of gross primary productivity (GPP) and community respiration (R) to define stream metabolic characteristics, and (4) long-term (6 weeks) additions of $^{15}NH_4$ at tracer levels to measure temporal and spatial (longitudinal) dynamics of nitrogen uptake, retention, and cycling rates through the stream ecosystem. The Walker Branch experiment began in April 1997 and will continue for about one year. Data from the Walker Branch experiment will be used with data from similar experiments at eight other sites to test hypotheses concerning relationships

between N uptake, cycling, and turnover and stream hydrodynamics, chemistry, and metabolism.

- affected by SNS construction, operation, or closure? No. This project will be completed in FY 1999. Nitrogen dynamics is a long-term area of priority research for WBW.

5. **Development of Gene Probes for Nitrate Reduction in Environmental Media: A Tool to Evaluate Nitrogen Retention in Watersheds**. This research is developing and field testing molecular detection and quantification methods for assimilatory and dissimilatory nitrate reductase in environmental media (soils, aquatic sediments). Signature gene sequences for specific nitrate reductase types are being identified and used to amplify natural DNA and mRNA templates for quantification of biomass and activity. These methods will then be tested across natural gradients in nitrate availability in forest soils and stream sediments.

   - affected by SNS construction, operation, or closure? No; project completed in FY 1999.

6. **Experimental and Theoretical Studies on the Seasonal, Annual, and Inter-Annual Exchange of Water Vapor and Energy Exchange by a Temperate Forest Ecosystem in the Mississippi River Basin**. This project addresses a GCIP program objective to determine and explain seasonal, annual and inter-annual variability of water and energy cycles in the eastern portion of the Mississippi River basin. Our overarching goal is to use micrometeorological (eddy covariance), physiological (sap-flow) and hydrological (watershed) methods to quantify the seasonal and inter-annual rates of water vapor and energy exchange over a temperate, deciduous, broad-leaved forest, and ecosystem of major significance in the Mississippi River basin. This approach will allow us to study the impact of environmental, phenological, and ecological factors on the intra- and inter-annual variations of water vapor exchange at three important spatial scales, the tree, the canopy, and the watershed. In conjunction with this project, two coupled land-atmosphere energy exchange models are being developed and tested (CANVEG and INTRASTAND), that account for phenology and water deficits. Then, using a ten-year record of climate data, the roles of climate, phenology and leaf area are being examined on the year to year range of annual evaporation and energy balance partitioning.

   - affected by SNS construction, operation, or closure? No; project completes in FY 2000. Eddy covariance portion of project is done by NOAA/ATDD. Seek their comments on potential impact to eddy covariance measurements, as they are relevant to that portion of this project, as well, and would potentially affect follow-on work based on this line of investigation.

7. **Theoretical Studies of the Annual Exchange of CO_2 and Energy by a Temperate Forest Ecosystem**. A detailed model of deciduous forest ecosystem physiology and physics (LaRS) is being used to simulate responses of the forest near the NOAA/ATDD forest meteorology research site on Walker Branch Watershed to the environmental factors of air temperature, rainfall, wind speed, solar irradiance, atmospheric humidity, and atmospheric CO_2 concentration. The model simulations will be compared to independent measurements made at the research site. The model includes submodels of: leaf phenology and growth, bole growth, root growth, leaf respiration, bole respiration, root respiration, soil respiration, leaf photosynthesis, and photorespiration, soil surface evaporation, stomatal conductance, transpiration and root water uptake, soil surface sensible heat exchange, canopy sensible heat exchange, canopy radiation balance, soil surface radiation balance, vertical water transport within the soil profile, vertical heat transport within the soil profile, and ecosystem momentum exchange. The ultimate aim of model development and testing is to provide tools capable of realistically predicting terrestrial ecosystem responses to increasing atmospheric CO_2 concentration and any associated climate change. This capability is important because terrestrial ecosystem responses to global environmental change may be significant to the global carbon cycle and therefore, global climate.

   - affected by SNS construction, operation, or closure? Potentially; Current project completed in FY 1999. However, a continuation proposal is anticipated. This work is linked to eddy covariance measurements conducted by NOAA/ATDD, and future work would potentially be impacted accordingly (seek NOAA/ATDD comments in this regard).

8. **Use of Multiscale Biophysical Models for Ecological Assessment: Applications in the Southeast**. Integrated biophysical models are being used to evaluate the predictable variability in four fundamental indicators of ecosystem condition: (1) spatial and temporal variation in primary productivity; (2) spatial variation in soil carbon and hydrologic storage capacity; (3) population size and dynamics of selected plant and animal species; and (4) bioaccumulation of lipophilic compounds in terrestrial and aquatic food webs. The basic physical models and model structure will be scale-independent, and applicable to scales ranging from first order watersheds to continents, with appropriate functional algorithms and parameterization. Implementations of the modeling system are being developed and tested at four spatial scales in the southeastern United States: 150km^2, 2000km^2, 150,000km^2, and the entire southeast. Primary data collection for net primary productivity and soil carbon and nitrogen dynamics are being collected on Walker Branch Watershed.

   - affected by SNS construction, operation, or closure? Not expected to be; current project completes in FY 1999, but follow-on work possible.

9. **Global Carbon Cycle Studies — Forest Soil Carbon Dynamics: Field Experiments and Model Validation**. Storage and properties of forest soil organic matter are being investigated along an elevation/climate gradient in the Southern Appalachian Mountains. Six sites, including Walker Branch Watershed on the ORNERP, were selected to span a range of temperature and moisture regimes, a range of soil N availability, and a range of forest community types. The sites were characterized with respect to differences in soil texture, pH, and aboveground carbon inputs. Soil moisture, air and soil temperatures, and the forest floor carbon dioxide flux were measured at regular intervals. Bulk soil carbon and nitrogen concentrations were measured to a depth of 30 cm. Patterns of abundance of ^{13}C in forest litter inputs, fine roots, and soil carbon at different depths were examined. Two climate variables are continuously monitored at each study site: (1) air temperature; and (2) soil temperature at a 10 cm soil depth. Between sampling intervals, throughfall is measured at each site as and indicator of precipitation inputs.

   - affected by SNS construction, operation, or closure? No expected effects.

Brief Description of Future Research Projects in the Walker Branch Watershed

The projects listed below are of two categories above and beyond the continuation of projects listed as currently ongoing. The first of these categories is projects for which funding proposals are pending; and the second, a category of activities which are in Environmental Sciences Division Strategic Planning goals and objectives, but for which funding proposals do not yet exist.

Proposals Pending

1. **Ecosystem Effects of Climate Change: Experimental Alteration of the Spatio-Temporal Pattern of Net Primary Productivity in a Deciduous Forest Ecosystem**. This project proposes to experimentally simulate the large-scale effects of atmospheric changes on the net primary productivity (NPP) of an eastern deciduous forest and its streams, with a focus on the ecosystem impacts of changes in the spatial and temporal variability in NPP that we expect will result from the manipulation. The proposed experiment is a multi-disciplinary collaboration between Oak Ridge National Laboratory and the University of Tennessee, which is submitting a separate proposal that will address ecological responses to the NPP alteration. This proposal focuses on establishing and maintaining the experimental treatments and quantifying both the driving variables and ecosystem responses in order to develop a mechanistic understanding of ecosystem responses to climate change at the landscape scale. The experiment will alter the mean level and spatial variability of soil nitrogen and phosphorus in replicated forested catchments. All catchments on both Pine Ridge (3) and Chestnut Ridge (1, WBW) will have a northwest aspect, and extend from ridgetop to valley bottom.

- affected by SNS construction? Catchment on WBW potentially impacted by dry deposition input during construction from dust, primarily. Could impact spatial variability in the experimental area, an element of the experiment. Impacts will be quanitfiable and would be negligible if control and treatment areas are equally affected.

- affected by SNS operation? All sites depend on precipitation chemistry and amount data currently measured at WBW NADP site. Experiment is planned for up to 10 years, so could potentially be impacted if NADP site is affected by SNS operation (currently unknown). This is important, since the NADP site is currently assumed to be representative of the local terrain. If operation should result in a localized effect on that monitoring site, it would negate that assumption, and would also compromise the long-term value of the site's data. Other historical and inactive deposition monitoring sites exist on WBW. Those sites could be activated to test impacts of SNS construction and operation on our single active NADP site and to cross-calibrate that site, but this would require additional funds. To mitigate impacts on this proposed project, additional, more intensive monitoring sites would need to be added for the WBW and Pine Ridge catchments.

- affected by SNS closure? No.

2. **Ecosystem Effects of Climate Change: Responses to Experimental Alteration of the Spatio-Temporal Pattern of Net Primary Productivity in a Deciduous Forest Ecosystem**. This project will evaluate responses to altered NPP at several trophic levels in both the terrestrial and aquatic portions of the ecosystem. It will use recently-implemented methods for estimating Leaf Area Index (LAI) from LandSat imagery to quantify the spatiotemporal dynamics of canopy leaf area responses to variation in nitrogen and water across the experimental and control catchments (described above). Plant responses at the herbaceous, subcanopy, and canopy levels will be quantified using a combination of methods to measure structural components and patterns of NPP. Animal responses will be evaluated using forest floor, canopy, and stream invertebrates, as well as small mammal populations. This project is a companion to the one described above, and is interdependent on it.

   - affected by SNS construction, operation, or closure? See comments above.

3. **Retention and Fate of Atmospheric Nitrogen Deposition in Forests: Tracer ^{15}N Addition Experiments in Forests of Contrasting Nitrogen Status**. Retention and fate of atmospheric nitrogen deposition to forests will be studied by conducting pulse ^{15}N addition experiments in tow forests of contrasting nitrogen status; Walker Branch on the Oak Ridge National Environmental Research Park, a highly nitrogen deficient forest, and Noland Divide in the Great Smokey Mountains National Park, a nitrogen saturated forest. Tracer-level additions of ^{15}N as nitrate and as ammonium will be made to forest plots

during rainfall events in winter and again in summer each year for three years. Uptake and incorporation of ^{15}N in various ecosystem nitrogen pools will be measured over time following each ^{15}N addition. The research will test hypotheses dealing with mechanisms responsible for uptake and retention of nitrogen deposition and differences in retention and fate of N in forests of differing nitrogen status.

- affected by SNS construction, operation, or closure? Project depends on input characterizations from NADP site. This work will be completed by FY 2001, but long-term research on nitrogen dynamics in deciduous forest ecosystems is a priority area of research for WBW. Potential for impacts on follow-on research could be managed by additional, more intensive deposition monitoring.

4. **The Effect of Field-Scale Climate Manipulation on the Dynamics of Dissolved Organic Matter in Soil: Implications for Soil Carbon Pools**. Comparisons of paired control- and climate-manipulation regimes will assess differences in the concentration and chemical nature of dissolved organic matter (DOM) in soil and shallow groundwater, determine decomposition rates of DOM, measure differences in the flux of DOM mobilized from soil through storm flow, and evaluate the interactive effects of altered CO_2, precipitation, and temperature on the fate and transport of DOM in soil using the TDE and FACE sites. These data form the basis of innovative approaches to carbon management, in which soils would be managed to optimize processes favoring the sequestration of large pools of carbon with long turnover times.

- affected by SNS construction, operation, or closure? Not anticipated at the present time, pending better information on potential temperature, water vapor, and hydrologic impacts. Project completion scheduled for FY 2001, but soil carbon management is a priority area for long-term research initiatives on WBW.

Strategic Initiatives

In addition to the future projects above, the Environmental Sciences Division Strategic Plan identifies Large Scale Environmental Process Research as a priority area in the future of the Division. This priority is based, in large part on the historical record of research and understanding of the ecological processes regulating ecosystem structure and function on the Oak Ridge NERP, including WBW. The research park is the cornerstone for large field experimental campaigns for decades to come. Future initiatives will include:

- A Large-scale manipulation of the interacting stress factors associated with climate change: Temperature, precipitation, carbon dioxide, and nutrient status.

- A major initiative in belowground science; understanding the physical, biological , and chemical environment of the belowground ecosystem.

8

- Climate warming manipulations, terrestrial and aquatic.
- Nitrogen dynamics of a deciduous forest ecosystem.
- Soil carbon management, carbon sequestration in forest ecosystems.
- The baseline of research and monitoring activities on the WBW are intended to contribute to a new national, interagency program for long-term ecosystem monitoring, with the experimental catchments on the Oak Ridge NERP as an index site in that network.

At the present time, it is not possible to speculate on the potential affect that the SNS might have on these initiatives, however given the concern over atmospheric measurements, and uncertainties that currently exist, it is likely that there would be some level of effect of the SNS siting that would need to be assessed relative to these future initiatives.

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